Contribution ID: **24** Type: **Oral**

Critical fluid volumes to start self-sustaining fracture ascent

Wednesday, 12 February 2020 12:24 (18 minutes)

In theory, pockets of fluid in brittle media can be transported large distances, provided that both the fluid volume is large enough, such that fluid pressures can fracture the rock, and that stress gradients exist causing asymmetric growth of the fracture's front. Currently, industrial injections are deemed safe based on empirical observations of volumes, rates and pressures from closed-access industrial data. Existing theoretical models are difficult to use a priori to predict the critical volume of fluid that will cause unhindered fracture ascent, as they are expressed in terms of the fracture's length, which is hard to predict a priori and difficult to measure. Here we constrain scale-independent critical volumes as a function of only rock and fluid properties by supplementing simple analytical models with numerical simulations in three dimensions. We apply our model to laboratory and natural settings, showing that the volumes we estimate match well with laboratory data and can be used as a conservative estimate in geological applications.

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Session Classification: Subsurface & Surface Processes

Track Classification: Subsurface & Surface Processes